

An Interdisciplinary Approach to Develop Key Spatial Characteristics that Satisfy the Millennial Generation in Learning and Work Environment

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Abstract:

The purpose of this paper is to explore essential spatial characteristics to create satisfying work and learning environment for the millennial generation. The millennial generation favors an environment that accommodates their ways of learning to promote a productive work environment. Focused interview, survey and research have been conducted to identify key physical attributes that satisfy the millennial generation. The data interpreted and translated the physical attributes and social-cultural characteristics of the millennial generation through the "Voronoi" diagram spatial characteristics. Within this approach, the concept of "Voronoi" diagram is articulated to define characteristics of spaces by mapping the combinations of key physical attributes. The methodology may be generalizable as a process to various demographic profiles, diagnosing their socio-cultural characteristics in spatial design. It may also be utilized as a tool to organize research information into theoretical frameworks that can guide projects and research in other disciplines.

Key Words:

Millennial Generation, Ways to Learn, Learning and Work Environment, Interdisciplinary, Spatial Characteristics.

Introduction

Nigel Cross (2006) says while scientists set out specifically to study problems, designers learn about the nature of the problem largely as a result of trying out solutions. Design problems deal with the multifaceted reality of the world. From the perspective of the built environment, problems not only pertain to structural or spatial issues but also to history, culture, and politics of the region. Many architecture and interior design problems are related to social phenomena with the relationship between human and the built environment. Consequently, in order to make sense of the nature of the problem in design, designers must examine the issue from multiple angles. Once designers understand the broad spectrum of a problem, the next step is to translate the research results for spatial and physical implications.

This study specifically explores interdisciplinary ways of constructing a spatial meaning of both physical attributes and social characteristics of the millennial generation in work and learning environments. The development of a theoretical framework begins with the idea of “system” that reflects the collaborative nature of the millennial generation. As an organizing and analyzing principle, the “Voronoi” diagram is utilized to illustrate a holistic system of key physical attributes and develop a relationship diagram that defines spatial characteristics which becomes a key basis (fundamental knowledge) of designing satisfying work and learning environment for the millennial generation.

"Voronoi" diagram is a mathematical concept that examines the relationship between the finite set of generating foci and its space in the given boundary. In this study, the concept of the diagram is interpreted in the relationship between socio-cultural characteristics and their needs for a productive work and learning environment. The target population is the millennial generation who will be significantly impacted by the design of work and learning environment because of their generational socio-cultural differences from past generations. The "Voronoi" diagram is utilized as a tool to develop a system that clarifies the relationship between the spatial characteristics that satisfy the millennial generation in learning and work environments.

Voronoi Diagram

The mathematician R. Descartes created the “Voronoi” diagram in the 17th century. The diagram is placed in the topic of computational geometry, and is based on the solar system and vortices. Descartes explained that the diagram is “a decomposition of space into convex regions, each consisting of matter revolving round one of the fixed stars” (Aurenhammer & Keln, 1999, p.1). The diagram illustrates the relationship between a finite set of isolated points and its regions within a given continuous space. The result of the concept is “a partitioning of the space into a set of regions” with “the closest member of the point set” (Okabe, Boots, Sugihara, & Chiu, 2000, p.1). It is a graphic depiction of the influence of the points, their relationship to edges in equal distance from the points, and the relationships among regions with shared boundary.

The “Voronoi” diagram is widely utilized in a variety of disciplines including; biology, chemistry, computational mechanics, geography, mathematics, medicine, physical science, terrain modeling, cell study, generative study, the study of pattern, neighborhood study and proximity graphs (Okabe, Boots, Sugihara, & Chiu, 2000, p.3). Its most interesting character is the boundary condition: “any two point sites are

connected whose regions have a boundary in common” (Aurenhammer & Kelin, 1999, p.2) as shown in Figure 1.

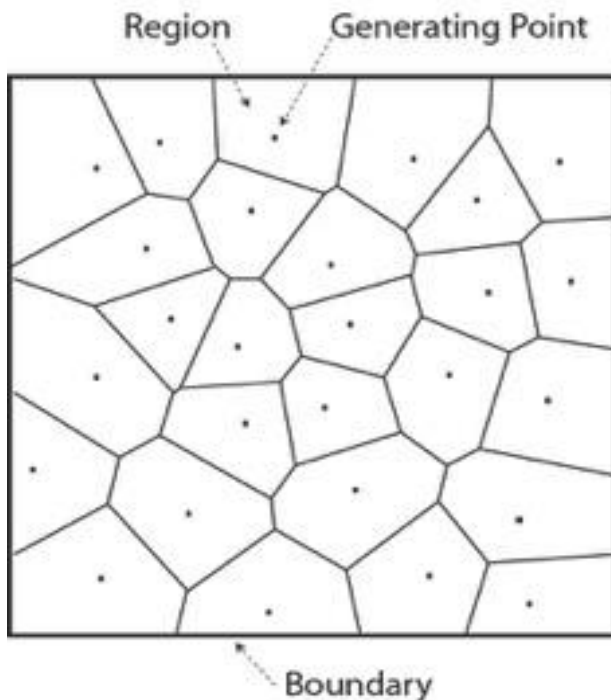


Figure 1. “Voronoi” diagram: relationship among point, region and boundary

The diagram’s structural properties suggest creative applications to various disciplines in constructing the relationship among variables. Looking at the world as a system and a composition of subsystems (Lazlo & Krippner, 1997), the “Voronoi” diagram is an appropriate fit for understanding, illustrating, and explaining social context. Lazlo and Krippner (1997) posited that numerous subsystems of a system are interrelated or interdependent to each other. Designers deal with multiple variables in a system. All components of the system are connected in various ways. Considering our society as a system, the built environment is a sub-system of society. People live, work, and learn in these built environments. Peoples’ needs and wants must be reflected in a built environment in order for them to comfortably inhabit in the space. When a designer considers socio-cultural characteristics of a population, that demographic can be reinterpreted from the concept of the “Voronoi” diagram: population characteristics, preferences and needs are the generating points of given spaces or regions. Members of the population are the points of impact to changes of the built environment. The interpretation of the “Voronoi” diagram as social context illustrates a rational framework for research of a population and its relationship to a specific space (Figure 2).

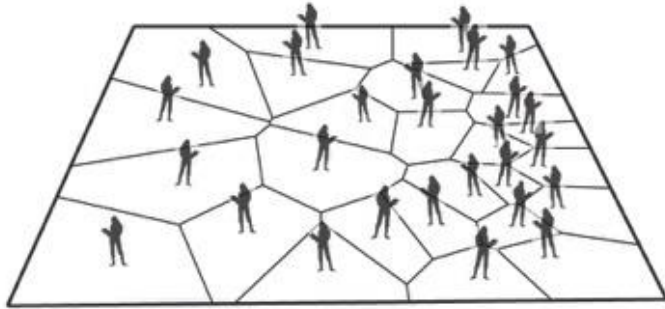


Figure 2. Understanding the “Voronoi” diagram in social context suggest generating points are members of the population

Literature Review

Relationship among the Voronoi, Generations and Work Environment

The work environment is the major living domain where people interact and spend time other than their homes (Duffy, 2002). Previous studies have demonstrated that references and needs of workers impact the workplace design such that office environments are a reflection of social transformation and cultural progress (Albrecht & Broikos, 2001). This implies that if workers’ wants and needs change, the workplace must accommodate the change in order to optimize satisfaction and performance. Today’s organizations face the challenge of a changing workforce with 76 million people of the millennial generation born 1981-2000 entering the workplace outnumbering the baby boomers born 1946-1962. The millennial generation brings new perspectives to the workplace, and the members are new points of impact for the society in the reflection of the “Voronoi” diagram. Consequently, the question of how work environment design can accommodate the millennial generation’s workplace needs arises. Finding a design solution to this complex problem starts from understanding the unique socio-cultural characteristics of the millennial generation and work environment as a physical setting. Considering members of the millennial generation as generating points of the region in the concept of the “Voronoi” diagram, the more specific question is: what unique physical characteristics will satisfy their needs and preferences. The concept of the “Voronoi” diagram is later utilized in developing a theoretical framework to describe how the specific socio-cultural characteristics of population inform the spatial design.

Generational Differences

Due to different historical events and social changes that each generation experiences, distinctive perspectives about life and work may be developed. Each generation has unique socio-cultural characteristics different from others generations (Table 1).

Table 1. Distinctive qualities of previous generations at work. (Cheung, 2007 as cited in Weingarten, 2008)

Generation	Milestones	Characteristics
Baby Boomers (1946-1964)	Assassinations of political icons Civil Rights Movement Women’s Rights Movement The Vietnam War	Optimism Team Orientation Work for personal fulfillment Dedication, Loyalty
Generation X (1965-1980)	Impeachment of President Nixon Fall of the Berlin Wall MTV Increase divorce rates HIV/AIDS Introduction of computers	Skeptical Cynical Independent Nonconformist Informal
Millennial Generation (1980-2000)	The Age of Technology Online social networking Terrorism, Iraq War Natural disasters The obesity epidemic Pop culture	Confident Demanding, Impatient Lack of job loyalty Social Diverse Value education

Generational characteristics also have an impact on how members work and what they value in the work environment (Table 2). Thus, each generation also has different purpose and expectations in the workplace.

Table 2. Work style Matrix illustrating generational differences. (Salkowitz, 2008, p.58)

Work style Issue	Baby Boomers	Generation X	Millennial Generation
Motivation for work	Gain status through achievement Personal impact Save for impending retirement	Enable lifestyle Realize creative or entrepreneurial vision Economic security and independence	Make social impact Satisfy high expectations Learning and personal development
Trust and Transparency	Trusts philosophies and ideologies, not institutions Expects that commitments will be honored	Distrusts authority Wants proof Skeptical of commitments	Trusts parents, teachers, and guiding figures Sees popularity as validation Wants to hear the big picture
Management Style	Interpersonal, team oriented Politics and unspoken relationships important Command-and-control, hierarchical	Individualistic, results-oriented Less attached to process Impatient with structure	Insufficient evidence
Communication Style	Self-consciously inclusive, politically correct Indirect and euphemistic Sees value in packaged communication	Informal, sometimes abrupt Values authenticity over sparing feelings Distrusts slogans and buzzwords	Eager to please, conflict averse Inclusive by nature Content of communication less important than act of communicating

The Millennial Generation

The millennial generation includes people who were born between 1981 and 2000. Unlike previous generations, this generation has proven difficult to recruit and retain in the workplace (Weingarten, 2008). Instead of a lifetime career like their predecessors, they are likely to change careers/jobs for dynamic and intellectual stimulation and learning opportunities at work (Weingarten, 2008, p.3). Research also indicates that the millennial generation is an interdependent, collaborative, and technologically driven group who will change future workplace trends based on the socio-cultural experiences of their youth (Firlik, 2006, p.2). Many companies are concerned about possible clashes between this new generation’s needs and wants and what is provided in the current workplace. In order to minimize potential conflict and to find out what changes may be needed in the work environment to recruit and retain the millennial generation, designers must understand how the millennial generation is different than previous generations and the millennial generation’s unique characteristics, values, and culture (Table 3).

Table 3. Comparison of socio-cultural characteristics of the millennial generation

Howe & Strauss (2000)	Coomes & DeBard (2004)	Lancaster & Stillman (2003)
Protected (sheltered) Optimistic Team-oriented Accept authority Rule followers Smart Confident Ethnically diverse Special Achieving Pressured to excel in everything Conventional More affluent Healthier Social Family values Multi-tasking Outer-driven, ideal-following team players Value community Technology expert Global generation	Ethnically diverse The Largest Cohort in the nation’s history (33% larger than the Baby Boomer generation) Cutting-edge Value education Reciprocity and Cooperation Active Learning Want feedback Time on task High expectations on performance Technology-driven Social	Globally concerned Realistic “Personal safety” is number one concern Value diversity Open to changes Want work to be meaningful Optimistic Interdependent Technological Superior Social

The Millennial Generation and Physical Characteristics of the Workplace

Although there are significantly large studies investigating the millennial generation and work style, study of the millennial generation and their physical work environment is limited. The company Steelcase with the Helen Hamlyn Research Center of the Royal College of Art, London, along with IDEO and Duffy Ely Giffone Worthington (DEGW) investigated the millennial generation and future work environment. Firlik (2006) proposes seven design recommendations that should be incorporated in the work

environment for “attracting and retaining millennial generation” (Firlik, 2006, p.6).
Optimal work and learning areas for millennials provide a/an:

- Fun space
- Open space
- Collaborative space
- Flexible space and workstations
- Personalized workstation design
- Visual display everywhere
- Technology environment (plug 'n' play, wireless)

Although Firlik's study does not present rigorous data or validation of the process, it does suggest a need of in-depth investigation about the relationship between the millennial generation and physical place of work and learning. The current study uses the Steelcase company seven-design recommendations as an initial tool to explore and understand the relationship between physical attributes and socio-cultural characteristics of the millennial generation. The goal was to find key physical attributes and develop spatial characteristics that can create a productive and satisfying work environment for the millennial generation. The process of the study demonstrates how their socio-cultural characteristics inform the physical requirements of their work environment.

Ways of Learning

People learn in different ways (Kolb, 1984). There are over 70 different ways in which we learn (Coffield, 2004). Historically, social scientist has referred to this concept as learning styles, which include three main broad cognitive categories, visual, auditory and kinesthetic (Wong, 2006). Recently, there has been research to suggest this term may not be accurate and there may be flaws in thinking about learning as a style. Researchers, such as Howard Gardner have viewed this concept as multiple intelligences. Gardner (1991) has categorized eight, Visual-Spatial, Bodily kinesthetic, Musical, Interpersonal, Intrapersonal, Linguistic, Naturalistic and Logical Mathematical. Gardner argues that the idea of learning styles is more of "a hypothesis of how an individual approaches a range of materials". There is no direct evidence to support the idea of matching learning styles to instructional activities improves learning (Pashler et al., 2009). Instead, they believe the best approach is to align instruction with content, and there may be better ways to teach different concepts. To avoid confounding the issue of this paper, we will use the term ways of learning, which has been accepted by most social scientist. Ways of learning is an ideal path that each of us takes to engage in conceptual understanding that allows us to process the information subsequently in a meaningful way. This approach aligns with the information processing model (Atkinson, & Shiffrin, 1968) transferring information from working to long term memory; and how Schunk (1996) defines learning as:

- a behavioral change, or change in the capacity for behavior;
- a change that endures over time; and
- occurring through practice or experience.

Therefore, ways of learning are an integral part of process and use information, which can vary from person to person and through generations.

Millennial Generation Ways of Learning

People in the millennial generation, generally born between 1981 and 1999 (Lancaster & Stillman, 2002), have become a popular topic for many reasons, including retail to education. The concept itself has produced many references such as Generation Y, Nexters, Echo Boomers, Digital Natives, Generation Next, and Generation Me (Price, 2009). In summary, Price (2011) identified five major attributes, which aid in Millennial learning, which include active learning methods; the need to make learning outcomes and activities relevant; require a rationale for specific policies and assignments; prefer a less formal learning environment; and are extremely relational. Therefore, we may need to reexamine our instructional methodology to attend to these new learners and create the most effective authentic learning environments. Roberts, Newmann, and Schwartzstein (2002) identified twelve tips for facilitating millennial learning. Several addressed the learning environment, such as Millennials value aesthetically appealing educational presentations; value the importance of collaboration; curiosity and exploration; and need help in understanding the limits of multitasking. Each of these characteristics can be addressed by intentional design. Perhaps an important perspective that educators may need to integrate that the mindset of a Millennial is different than students of the past. Millennial students favor active ways of learning. Dede (2005) has found this hyperactive approach can be viewed as mediated immersion. The immersion involves fluency in multiple media and simulation-based virtual settings; communal learning involving diverse, tacit, situated experience, with knowledge distributed across a community and a context as well as within an individual; a balance among experiential learning, guided mentoring and collective reflection; expression through nonlinear, associational webs of representations rather than linear lecture. Diana Oblinger (2003), believes for millennials, computers aren't technology; the Internet is better than TV; reality is no longer real; doing is more important than knowing; learning more closely resembles Nintendo than logic; typing is preferred to handwriting; staying connected is essential; things are on demand, they have zero tolerance for delays; and consumer and creator are blurring. Finally, Millennial learners are eager to embrace social justice issues and believe in situation cognition, which means context and the environment becomes even more important (Dede, 2005).

Effective Learning and Working Environments

Learning is not a spectator sport, whether on a college campus or at a place of business. Students must talk, write, connect and apply about what they are learning (Chickering, & Gamson, 1987). There are attributes that can encourage effective learning and work, which primarily center on identifying ways to engage people in meaningful conversations. Hargis and Schroeder (2010) found that manipulatables, such as moveable whiteboards improved learners' ownership of content, empowered a broader sense of voice and encourage them to create representations of what they learned. Peter Barrett (2012) found that the learning environment could affect academic progress by as much as 25%. Six design parameters—color, choice, complexity, flexibility, connection, and light—were found to have a significant effect on learning.

Therefore, sufficient research exist that clearly demonstrates what constitutes an effective learning and working environment. The question appears to be how willing are we, as facilitators of learning to modify our pedagogy.

Methodology

A stratified sampling method randomized within target groups under probability methods was used. Data were collected during the final six-week period in the fall semester, 2008. Focused interview and survey questionnaire were informed consent as per an Institution Review Board (IRB) requirement.

Based on the Steelcase company's seven recommended spaces, both a focused interview questionnaire and a survey were developed. Masters of Business Administration (MBA) students, ages 21 to 28, were recruited to participate in this study. This specific group was chosen because their ages suggest membership in the millennial generation. Their educational experiences indicate they had likely been exposed to an office work environment and expect to work in such an environment after graduation.

Procedure

With the permission from professors of graduate business classes of a University, 18 surveys were distributed to on November 5, 2008. The researcher distributed the surveys at the beginning of class, with a 10-minute time frame for completion. The interviewer was present in the classroom to answer any questions from the participants. Another 27 surveys were distributed on November 10, 2008 in the same manner.

Participants

A total of 45 students from two different classes in a University MBA program were recruited. Twenty-two male students (mean age: 24) and twenty-three female students (mean age: 24) participated. Among the 45 students, 14 students were international students.

Focused Interview

Six students from a University MBA program were recruited for the interviews. Five female students and one male student participated. The mean age of the participants was 24, and they all either previously or currently had jobs in an office environment. The purpose of the interview was to confirm whether the Steelcase company seven design recommendations are the most desired physical attributes for the millennial generation. An additional goal of the interview was to ascertain if there were other, additional physical characteristics desired for the office work environment for the millennial generation.

Interviews included two sets of questions: the first set of questions was about preferences of workspace, and the second set was about the characteristics of workplace regarding Steelcase company seven recommendations. The interviews were conducted on October 22, 2008, and the duration of the interviews was an hour and a half, from 4:00 pm to 5:30 pm. The format of the interviews included a group interview where all six students were interviewed together in a conference room. The Interviewer asked questions to the group, and they were encouraged to answer questions in a

casual manner. A digital voice recording of their responses was collected with the permission of the participants throughout the interview for data.

Focused Interview Questionnaire

Regarding Preferences in Workplace:

1. How do you feel about the overall current design of the office?
2. What kind of workspace do you prefer to work individually?
3. Do you think that informal group meetings are productive?
4. What does technology mean to you for your individual and group work?
5. How is it important in terms of your job satisfaction?
6. What kind of additional space do you think you need in your workplace from current typical workplace?

Regarding Steelcase company's seven design recommendations for the Millennial Learner:

1. What does "fun" mean to you in your workplace?
2. What does "open" mean to you in your workplace?
3. What does "collaborative" mean to you in your workplace?
4. What does "flexible" mean to you in your workplace?
5. What does "personalization" mean to you in your workplace?
6. What does "visual display" mean to you in your workplace?
7. What does a "tech environment" mean to you in your workplace?
8. What other physical characteristics that may be important to your workplace?

Additional Questions:

1. What would be 3 most important physical characteristics for your workplace?
2. What other concerns do you have in your workplace?

Focused Interview Outcome

A content analysis was performed to understand preferences and meanings of the Steelcase company's seven-design recommendations and their additional desired physical characteristics in the workplace. Adding to Steelcase's seven-design recommendations, six more desired physical characteristics were identified from the interview – acoustical privacy, natural light, view, color, furniture, and control of ambient conditions. Participants identified five of the Steelcase recommendations as important to the participants: Fun space, Open space, Collaborative space, Flexible space and workstations, Tech environment (plug 'n' play, wireless). Personalization and visual display were the least important physical attributes to this interview group. Based on the results of focused interview, a survey questionnaire was developed.

Survey

A paper-based survey was conducted to refine the millennial generation's desired physical characteristics in the workplace. Survey questions included probes for individual and group workspaces as well as technology-implementation. Two sets of questions were developed: one set asked for overall desirable physical characteristics in the work environment. The other set presented images of individual and group work places. From the set of images, participants were asked to choose their favorite pictures, write their reasons of the choice, and then evaluate the picture in terms of physical characteristics. A paper-based survey was distributed to forty-five MBA students to refine the outcomes of the focused interview and to discover what physical characteristics of office environment are the most important for the millennial generation. The survey can be found at <https://goo.gl/WfC4eQ>.

Survey Questionnaire Overview

Question 1: Verbal Understanding

Based on the given definitions and participants' own understanding of each physical characteristic, participants were asked to choose every possible important physical characteristic of their work environment and then write down the three most important characteristics from the list of 13 physical characteristics:

- Acoustical Privacy
- Natural Light
- Views
- Fun
- Open
- Collaboration
- Flexibility
- Personalization
- Visual Displays
- Technology
- Color
- Furniture
- Ambient Conditions

Question 2: Photo Study

The purpose of the photo study was to determine how selected physical characteristics are desired in individual workspaces and group workspaces. Eight photographs of individual workspace were presented on a paper, and the participants were asked to choose their favorite workplace according to the information provided in the picture and write down three reasons for the choice. Then, the survey required them to evaluate the picture regarding the thirteen physical characteristics by ranking the appropriate points. Three pictures of group workspaces were given, and the same questions were asked.

The rationality of choosing photos of each individual workspace and group workspace was to mix thirteen physical characteristics, so the responses from the

participants can be unbiased and valid. The rationality for each photograph is discussed based on the thirteen physical characteristics.

Survey Findings

From question 1: verbal understanding, fun, flexibility, and technology were identified as the most important characteristics for satisfying work environment.

For individual work environment, color, fun, natural light, open, visual display, technology, and flexibility were the characteristics that attracted participants for their individual work environment. Collaboration, open, natural light, fun, color, and view were identified as the dominant characteristics that participants desire to have in their group work environment. Overall, survey question results indicate that fun, open, acoustical privacy; collaboration and natural light are the most important physical characteristics of workspaces for the millennial generation. Personalization and visual display were identified as the characteristics of least concern for the millennial generation, which differs from the Steelcase company design recommendations.

The physical attributes that are identified from the Steelcase company study, focused interview emphasized the key physical attributes to create satisfying work and learning environment. With the advancement of technology, the implementation of the attributes became faster and more flexible. For instance, the ways to collaborate among students have been expanded in scale and effort. Collaborative work became more natural as an activity for them to engage in class. Students of the millennial generation now collaborate through software applications of mobile devices. The millennial generation, has therefore re-deigned the concept of collaboration as more than group work. Collaboration, with the addition of functional technology has now become the means of active learning among people. Instead of one-way directional relationship among students and teachers, multi-directional asynchronous interaction is possible. With the flexibility and speed that are provided by appropriate technology, active learning becomes a part of learning and work environment that encourage various activities to learn the subject in a dynamic way. The concept of “fun” today has been intellectually evolved by this generation with the emphasis of meaningful work in a collaborative setting. Students now understand that their current studies parallel the type of work, which will be expected of them in their careers. Therefore, collaboration is not perceived as complex coordinating task among different people but as fun and engaging work among people with a common shared goal. While they value the collaborative work, they value physical attribute of privacy that allow them to focus their own growth and learning as well.

Based on this research result from 2008 and the anecdotal observation of millennial generation in today's work and learning environment, the interior design project focused on fun, privacy, and collaboration as main physical attributes in building theoretical framework and developing spatial characteristics to create satisfying work environment for the millennial generation.

Connecting the Voronoi, Research, and Design

The “Voronoi” diagram is articulated in the context of design problem, considering fun, collaboration, and privacy as boundary points of the polygon that defines the domain of millennial generation and work environment. Constructing a triangle

combination of three physical attributes generates each subsystem. By assigning two boundary points with same physical attribute and the other point with one of remaining two attributes, a total of six combinations of subsystems can be constructed (Figure 3).

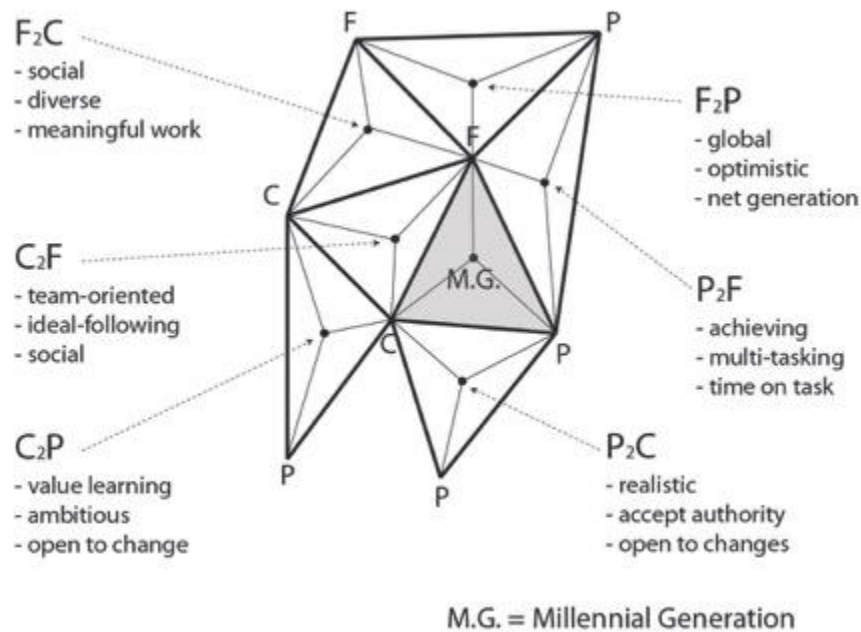


Figure 3. Six subsystems that translate as six essential spaces relating to socio-cultural characteristics of millennial generation; F: Fun, C: Collaboration, P: Privacy

Identifying Six Essential Spaces

The generating point for each combination refers to a socio-cultural characteristic of the millennial generation. Figure 4 shows the visual mapping of developing six essential spaces. It demonstrates how six spatial characteristics from Figure 3 are refined to create six spaces; F₂C, F₂P, C₂F, C₂P, P₂F, and P₂C. This combination prioritizes and emphasizes each physical attribute, defining the most essential spaces for a satisfying work environment, which have been identified in the interview and survey.

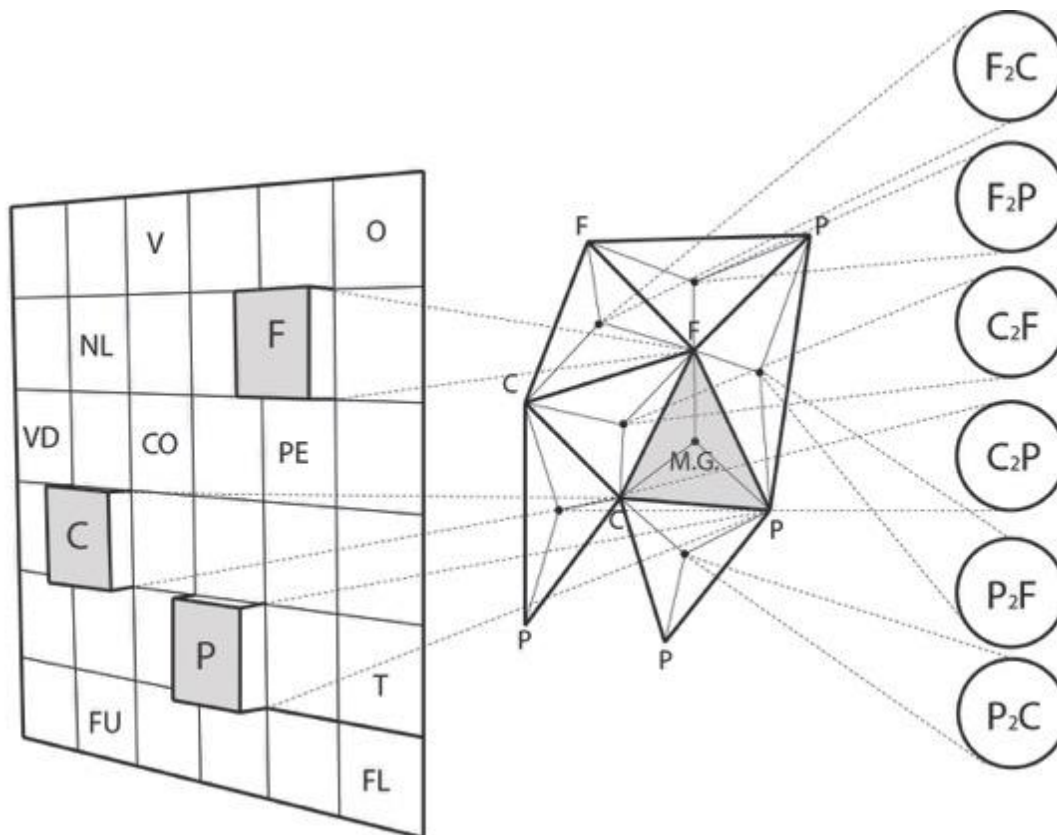








Figure 4. The visual mapping demonstrates the development of six essential spaces; F: Fun, C: Collaboration, P: Privacy

For example, the combination of fun and privacy suggests a priority for a private comfortable space that provides alone time with the option to be social. The combination of privacy, collaboration suggests privacy emphasized collaborative space, such as formal, professional meeting or a conference room.

Defining six spatial characteristics

Six essential spaces embody the socio-cultural characteristics defining the function and character of each physical space. Table 4 describes spatial characteristics and corresponding physical properties. This shows how the unique social characteristics of the millennial generation inform the characteristics of the six essential, integrated spaces.

Table 4. Descriptions of spatial characteristics and corresponding physical properties

Space	Characteristics	Physical Properties
<p>Play</p>  <p>= FFC = (F*2) + C = enjoyable emphasized collaborative space</p>	Active, social, game-fun	Ability to close, natural light, technology, flexibility, color
<p>Relax</p>  <p>= FFP = (F*2) + P = enjoyable emphasized privacy space</p>	Comfortable, quiet, fun, providing alone time, social	Ability to close, views, natural light, technology, flexibility, color, comfortable furniture
<p>Imagine</p>  <p>= CCF = (C*2) + F = collaboration emphasized fun space</p>	Brainstorming, idea generating, social	Ability to partially enclose, views, natural light, technology, flexibility, color, comfortable furniture
<p>Learn</p>  <p>= CCP = (C*2) + P = collaboration emphasized privacy space</p>	Interactive learning atmosphere, sharing knowledge	Ability to enclose, views, natural light, technology, flexibility, color, comfortable furniture
<p>My Space</p>  <p>= PPF = (P*2) + F = privacy emphasized fun space</p>	Focus, personal workstation, private	Ability to partially enclose, views, natural light, technology, flexibility, color, comfortable furniture
<p>Integrate</p>  <p>= PPC = (P*2) + C = privacy emphasized collaboration space</p>	Formal, professional	Ability to close, views, natural light, technology, flexibility, color, comfortable furniture

Theoretical Framework: Relationship among Six Essential Spaces

Each character of six subsystems can be synthesized into a relationship diagram. This diagram is the theoretical framework providing a prototype for the spatial relationship among six essential spaces (Figure 5). The research outcomes indicate that

collaboration is the key characteristic that distinguishes the millennial generation. Having the collaboration-emphasized-fun space (C₂F) at the core, the overall collaborative atmosphere can be established. C₂P, P₂C, and P₂F have a close relationship to each other in terms of the work process from idea generating and learning, executing the work to the final product in P₂C. F₂P and F₂C independently exist with a close relation to C₂F. Two such spaces suggest the quality of a workspace that may provide stress-relief and active social interactions. The technical descriptors (F₂P, F₂C, C₂F, C₂P, P₂C, P₂F) are more aptly renamed with a social context such as relax, play, imagine, learn, integrate, and my space.

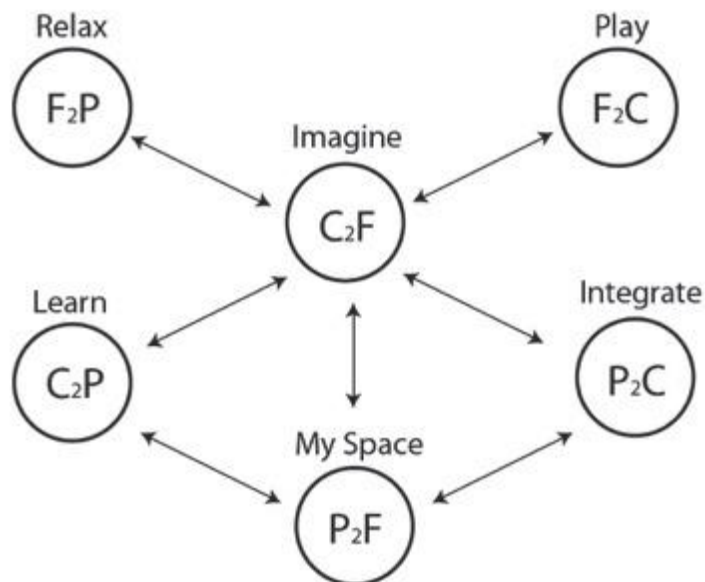


Figure 5. Theoretical framework interpreting the relationship among six essential physical spaces: Relax, Play, Imagine, Learning, Integrate, and My Space

Discussion

As designers deal with the multifaceted variables in a given project, there are many cases that call educators' creative ability to look at a subject in different perspectives. Not many people would initially consider that the theoretical framework in Interior Design could be established through a mathematical concept. However, the disciplines are inter-connected in ways that it may be beneficial for educators to consider alternate possibilities of understanding these systems and their relationship within their own discipline. An interdisciplinary approach of understanding the world enriches and broadens our perspective as well as the connectiveness between disciplines. As the millennial generation becomes predominant generational group who work in an interdisciplinary manner in both work and learning environment, the study proposes a way of understanding the relationship between socio-cultural characteristics of millennial generation and spatial characteristics that inform to design satisfying work and learning environment for them with an interdisciplinary approach. Since the "Voronoi" diagram's structural properties suggest creative applications to various disciplines in constructing the relationship among variables, this approach was possible. Its concept was useful to connect between variables of research about this certain demographic and its visualization understanding of physical spatial characteristics.

We realize there is a gap between when the study was conducted in 2008 and the date of finalizing this paper. We also realize that generational gaps, and the speed of introduction to adoption of information technology has increased exponentially. As to the potential differences that might have occurred with our study group, we have considered certain indicator behaviors that we believe allow us to consider our study group and today's students as a homogenous population. Examples of behaviors, which have been observed in our classes of similar demographics this semester, include self-initiation of forming a group to research, which reflects their value of collaborative work. If the scope of the research seemed too big, today's students already understand that collaborative work would be more effective than individual researching. Their ways of collaboration has been significantly digitalized today comparing to the ways that people collaborate in 2008. Since the use of mobile device is familiar to this generation, today's students communicate their ideas by uploading pictures and texting instantly without step-by-step instruction from a teacher. Various ways to share and communicate through available digital tools allow our students to feel "fun" when they are collaborating with others. The students also value the degree of privacy that allows them to focus seriously on their work, so they can present their work well. We witness today's students seek the balance among three key physical attributes; fun, collaboration and privacy in their learning and work environment today. These behaviors allow us to consider key physical attributes in 2008, which are still important factors.

Conclusion

Although this study was specifically focused in the discipline of Interior Design, an interdisciplinary approach to research methodology and theoretical framework through the "Voronoi" diagram proposes a possibility that other disciplines can adopt this way to think how research outcomes can be organized, extracted, analyzed and synthesized to construct own meaning to the given project. This also can be used to find key factors that are affecting certain behavior, phenomenon or event in other disciplines. The way of utilizing the "Voronoi" diagram for creating combinations of physical attributes allow designers, researchers, educators, and students to develop unique meaning that reflect needs of certain demographic socio-cultural characteristics in a systematic manner. The use of combinations within "Voronoi" diagram suggests how empirical research can be presented in a graphic format in the way of finding key factors through the interdisciplinary lens. Finally, we believe that the use of the Voronoi model for teaching and learning can be scaled for other topics and disciplines. For example, other disciplines such as Business can use this approach to create a framework that provide deeper understanding of the relationship between their target demographics and cost structure or revenue streams. "Voronoi" diagram can be utilized to describe the relationship among key activities of certain business profit value chain in this case. In teaching and learning itself, the model provides a way to establish a relationship between socio-cultural characteristics of our students' demographic and given subject's key learning points that encourage teachers to be interactive with students for building the understanding of a subject in the context of what matters to the needs and wants of our students.

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